

SPECTROSCOPIC ASPECTS OF DIFFERENTIAL METHOD FOR  
SOUNDING GAS COMPOSITION OF THE ATMOSPHERE

V.V.Zuev, I.I.Ippolitov, Yu.N.Ponomarev  
The Institute of Atmospheric Optics, Siberian  
Branch, USSR Academy of Sciences, Tomsk, 634055  
U S S R

The remote sounding of atmospheric gases by the differential absorption method has been widely developed at present [1,2]. The extension of the method suggested in [3] allows one to measure both the concentration of an absorbing molecular component and the gas temperature. To realize the differential absorption method, one should analyze in detail not only the spectrum investigated but also the spectra of the other molecular components of air whose absorption lines are near the sounding-radiation frequencies. This is necessary for both determining the contribution from absorption by foreign gases to a lidar return and for choosing the sounding frequencies  $\nu_1$  and  $\nu_2$ . The optimal values  $\nu_1$  and  $\nu_2$  are found from the condition of maximum difference  $\Delta\sigma = \sigma(\nu_1) - \sigma(\nu_2)$ , where  $\sigma(\nu_1)$  is the absorption cross section in the sounded gas line,  $\sigma(\nu_2)$  out of the absorption line. The methods and techniques of sounding considered in [1-3] have been realized at radiation intensity not resulting in deviations of vibration-rotation level populations of the molecular medium from their equilibrium values and for successive sending of laser pulses at frequencies  $\nu_1$  and  $\nu_2$  into the investigated atmospheric volume. Paper [4] describes the possibility of utilizing the schemes and methods of double optical resonance spectroscopy when solving the problems on remote sounding. The method foresees the use of radiation at two frequencies simultaneously with the aim of primary population of the vibration-rotation transitions most convenient for sounding including those in hot bands.

The problems concerning the dynamics of populations of the sounded atmospheric-gas molecule levels taking into account the nonmonochromatic character of radiation (e.g. double frequency as in [4,5]), durations of exciting and sounding pulses, rates of relaxation of excited vibration-rotation states population along different channels (rotational, vibrational, and that of vibration-vibration exchange) in a natural multicomponent mixture of gases and air have been investigated in the paper.

The problems of spectroscopic software, completeness and accuracy of the initial spectroscopic information, information on channels and rates of relaxation from the viewpoint of developing specific schemes of sounding have been discussed. The values of deviations of vibration-rotation level populations of some atmospheric molecules ( $H_2O$ ,  $CO_2$ ,  $O_2$ ) from their equilibrium value at simultaneous action of double frequency radiation on the sounding path and the correspon-

ing dynamic variations of lidar-return amplitude have been estimated. The importance of nonlinear spectroscopic effects in the lidar return value variation at sounding radiation frequency equaling the resonance frequency of vibration-rotation transition in the problem on sounding the humidity profiles and concentrations of gaseous pollutants has also been estimated. The connection of the lidar-return characteristics at transmitting double-frequency laser radiation to the sounded volume with the values of meteorological parameters  $\rho$  and  $\theta$  has been discussed, and the solution of the inverse problem on restituting these parameters has been considered.

#### References

1. Laser monitoring of the atmosphere. Ed. E.D.Hinkley. - Moscow, Mir, 1979, 416 p.
2. Spectroscopic methods for sounding the atmosphere. Ed. I.V.Samokhvalov. - Novosibirsk, Nauka, 1985, 140 p.
3. J.Mason. Lidar measurement of temperature: A new approach. - Appl.Opt., 1975, v.14, N1, p.76-78.
4. R.M.Measures. PROBE: a new technique for measuring the density profile of a specific constituent using counter-propagating laser pulses. - Appl.Opt., 1977, v.16, N11, pp. 3016-3026.
5. O.K.Voitsekhovskaya, K.A.Zamaraev, V.V.Zuev, I.I.Ippolitov. Microwave sounding of atmospheric gases: new approach. - Izv. VUZov, Radiofizika, 1986, N5(to be published).